

THE SHEDDING OF THE STOMACH LINING BY BIRDS,
PARTICULARLY AS EXEMPLIFIED BY
THE ANATIDÆ.

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Plates XVI-XVII.

AT the beginning of this discussion, it is well to make sure that all understand the true nature of the stomach lining of birds. Besides the innermost lining with which we are now especially concerned, the stomach wall in birds consists of three layers: the external serous or connective tissue coat, the middle muscular layer, which varies greatly in development, in the different groups and the inner glandular or mucous coat. In section, as viewed through the microscope, the mucous coat is seen to consist chiefly of innumerable long slender villi. It is among these that the material is secreted that forms the innermost or fourth coat of the stomach. This lining is of a horny but somewhat flexible consistency. It strips rather easily from the mucous coat, and when freshly pulled off its inner surface has a furry appearance. When examined under the microscope the filaments giving it this appearance are seen to continue into the mucous coat. This interdigitation must aid greatly in holding the corneous lining in place, during the digestive process, which is a strenuous one, particularly in birds with highly developed grinding gizzards, as the Anatidæ.

To emphasize the intensity of the grinding process in which the stomach lining takes part, it may be well to give an idea of the power exerted by the gizzards of birds. De Reaumur found that small tin cylinders fed to turkeys were crushed by the gizzard in a short time; and pellets of shot in gizzards often are greatly flattened. Wild ducks habitually feed on such things as acorns and hickory nuts and have no difficulty in grinding them up. In fact, according to the writer's experience, bitter pecans which have a thick hard shell are cracked as they enter the gizzard, and before they can possibly have been exposed to the maximum pressure. Many species of ducks feed upon thick-shelled mollusks,

which they must of course swallow whole and grind up in their gizzards. Such species as the Scoters and Greater Scaup thus easily dispose of oysters.

It is evident that a mass of fragments of such shellfish, or even some softer food, interspersed with often sharply angular gravel, and subjected to grinding by the tremendous muscular power indicated, must have a powerful abrading effect upon the lining of the gizzard. Nothing is more natural to suppose, therefore, than that the lining wears out and must be replaced.

The stomach lining when fresh covers the whole interior of the organ, being thin about the openings into the stomach and on those parts of the wall between the great muscle masses. On the inner face of each main muscle-body, however, the lining is greatly thickened. This part of the lining is hereafter referred to by the term, pad. Each pad has a somewhat crescent-shaped, very firm grinding ridge which is opposed to the ridgeless end of its fellow pad.

The movements of the gizzard during trituration are such as to give the food mass a rotary motion. This we know from the arrangement of the longer particles in food taken from bird stomachs and from the appearance of the caterpillar hairs which remain sticking in the lining of cuckoo stomachs. The arrangement of these resembles that of the fibers on the top of a well-brushed silk hat.

The rotary movement of the gizzard contents, together with the presentation of the hard thick grinding ridge of one pad against the thinner, less durable portion of the pad on the other side, results in wear first becoming apparent on these thinner ends of the pads (Fig. 1). A little such wear reveals the fact that the pads have a stratified structure and the gradual approach of the ends of the strata toward the middle of the pad indicates the progress of the wear (Figs. 2 and 10). It may be that such wear is compensated for, at least in part, by addition to the pads from below, but eventually they become unserviceable and must be shed.

Often the wear takes the form of a rolling up of the ends of the pads, which are thus subjected to much greater stress (Figs. 8 and 9). Furthermore, in such case, food and grinding material getting under the pad tend to force it away from the mucous coat.

Wear is manifested also by the lining becoming longitudinally grooved, and by strips or broader fragments being gouged out (Figs. 3 to 7). In some cases the broken surface of the pad together with the shredded portions remaining in position, have a distinctly pathologic appearance, and make it hard to realize that one observes but a stage in a normal and periodically recurring process.

Apparently after the lining has reached a certain degree of wear, general shedding occurs. Then, all the thinner portions of the lining usually come off as well as the thick central pads. Rarely a bit of the old lining may cling, and if a piece of one of the pads, it stands out prominently from the new smooth surface. Such pieces gradually wear away from the new lining which bears them. Finding fragments of stomach lining among the food is by far the most common evidence of the shedding. No fewer than 5 large and 20 small pieces of lining have been found in a single stomach. It is certain that the normal process in the Anatidæ is, that the worn stomach lining is shed off, ground up, and passed out of the body through the intestines. Cases of the regurgitation of the lining are what are chiefly recorded in the literature, but in Anatidæ, regurgitation seems practically impossible.

When the central pads and other parts of the stomach lining are freshly shed off, the surface below is not always a new grinding surface, but may be the soft mucous coat itself. This is known by the fact that objects in the gizzard become imbedded in it, something that never happens (except in case of sharp bones, etc.) when the horny lining is concerned. Stomachs in this stage are empty or nearly so, and it is probable that there is a pause in digestive action until a new lining is formed. A useful incidental result of shedding the lining is that the bird gets rid of the parasitic worms (Nematodes) that frequently lie half beneath, half above the lining.

As to the frequency with which evidences of wear are observed, I may say that in a collection of 30 stomachs of ducks from Minot, Mass., 4, or 13% showed marked wear; the proportion in another lot of 67 from Wenham, Mass., was 24%. I have noted severe wear or some stage of the actual shedding process in about 100 gizzards of the common Mallard, 66 of the Lesser Scaup, 28 of the

Black Duck, etc. The number of species of ducks and geese in which the process has been observed is 24 and includes the following:

Merganser, Mallard, Black Duck, Florida Duck, Gadwall, Baldpate, Green-winged Teal, Blue-winged Teal, Shoveller, Pintail, Wood Duck, Redhead, Canvasback, Greater and Lesser Scaups, Ring-necked Duck, Goldeneye, Bufflehead, White-winged Scoter, Surf Scoter, Ruddy Duck, Blue Goose, Ross's Goose and Canada Goose.

In connection with the last named species it is interesting to note that Audubon described (though unwittingly) a case of the shedding of the stomach lining. He says:¹ "The epithelium forms two transversely elliptical, concave grinding surfaces, of great density (but it is altogether wanting on the rest of the inner surface, although this may have happened after death)." It is not surprising that the last thought occurred to him, as an explanation of the case, for things certainly do not look right inside a shedding gizzard. However, there is little doubt that that was just what he examined. A comparable case is shown in Fig. 11.

Birds other than Anatidæ for which we have found evidence of shedding the stomach lining are discussed by species, which number 11:

Royal Tern (*Sterna maxima*), Amelia Id., Fla., Nov. 26, 1906.—

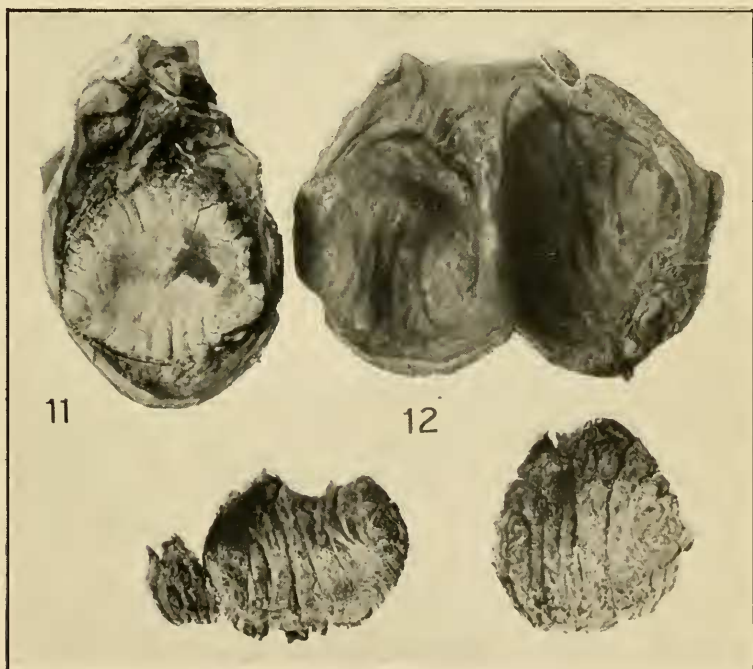
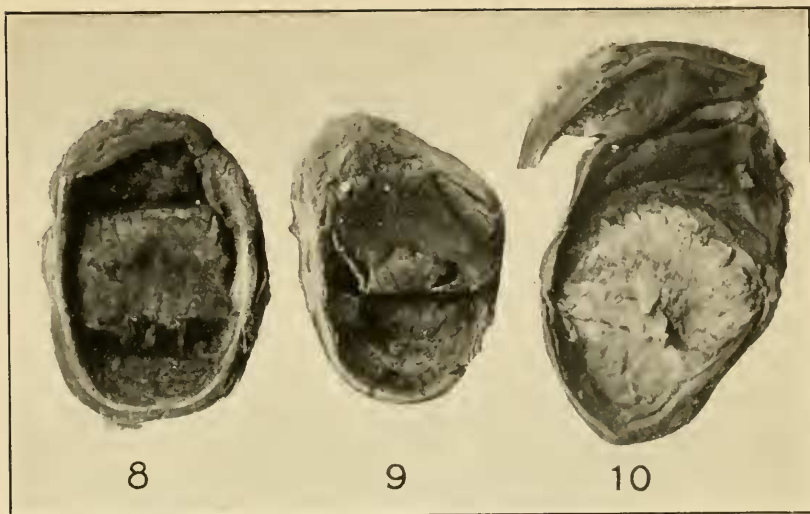
A large crescentic fold of the lining has been pushed away from the mucosa near œsophageal orifice, evidently by incoming food. If the bird had lived, there is little doubt that the entire lining would soon have sloughed off.

Black-necked Stilt (*Himantopus mexicanus*), St. Joseph Id., Tex., Aug. 14, 1905.—Stomach contained a shed lining in fragments, and the functional lining was cracked and separating readily, leaving a hard layer beneath.

Long-billed Dowitcher (*Macrorhamphus griseus scolopaceus*), Aransas Bay, Texas, August 14, 1905.—Lining entirely free from stomach wall, complete but broken into two pieces; next layer hard.

Bobwhite (*Colinus virginianus* subsp.), Gurley, Texas, July 19, 1905.—Entire lining very loose, with particles of food behind it on one side; next lining hard. Apparently this lining would have soon separated as a whole.

¹ Orn. Biogr. 5, 1849, p. 609.



STOMACH LINING OF DUCKS AND GEESE.
8-9 MALLARD, 10 AND 12 GREATER SCAUP,
11 ROSS'S GOOSE.

Sparrow Hawk (*Falco sparverius sparverius*), Navasota, Texas, October 11, 1905.

Yellow-billed Cuckoo (*Coccyzus americanus americanus*).—Have seen seven instances of shedding of lining in this species; six of them were in a lot of eleven stomachs.

Black-billed Cuckoo (*Coccyzus erythrophthalmus*).—In a lot of 6 stomachs heavily lined with caterpillar hairs, the lining of 5 was cracked and peeling off. It has been noticed that among cuckoos taken at the same place and time, some have the stomach lining furred with caterpillar hairs, while others lack them. The explanation of this may be frequent shedding of stomach linings.

Magpie (*Pica pica hudsonia*), Farmington, Utah, May 7, 1912.—Numerous pieces of old lining free in stomach, the largest tightly rolled up by muscular action of gizzard; new lining perfect.

Fish Crow (*Corvus ossifragus*) Norfolk, Va., December 20, 1890.

Southern Meadowlark (*Sturnella magna argutula*) Turtle Bayou, Texas, September 22, 1897.—Complete old lining somewhat worn and cracked, almost wholly separated from new lining, but still in position.

California Thrasher (*Toxostoma redivivum*) Watsonville, Calif., August 31, 1903.—This stomach shows a peculiar malformation—an inwardly projecting lobe. The lining had been molded over this of course, and the fact that the lining was shedding is shown by this hollow flap having sloughed off and its inner surfaces cohering.

Mockingbird (*Mimus polyglottos polyglottos*).—Five cases of shedding or incipient shedding noted.

Hermit Thrush (*Hylocichla guttata* subsp.) Allen's Park, Colo., September 28, 1905.

These species are scattered through the groups of birds in a way to suggest, that cases of the shedding of the stomach lining may eventually be observed in almost any species.

CONCLUSIONS.

A number of instances have been recorded in ornithological literature (see bibliography) of stomach linings being shed and regurgitated. This, of course, is the only form of the phenomenon